Queensland Government
Department of Primary Industries

DPI Notes

Selection and matching of tractors and implements: Darling Downs

Compiled by Graham Powell, Farming Systems Institute

To select and match tractors and implements, you will need information about the capacity of both the tractor and implement as well as the load that is likely to be imposed on the power unit.

Draft requirements will vary with implement design, soil type, speed of operation and depth of operation. Therefore in any matching situation there is an inherent danger in specifying a machine's capacity or power requirement unless actual field efficiencies and draft requirements have been measured. Accept specifications, therefore, with some caution.

Effective field capacity

The effective field capacity is the actual output achieved by a machine.

It is a function of the proportion of the machine width utilised, the travel speed and the amount of time lost in the field during the operation. Time is lost to implement blockages, working areas such as headlands more than once, adjustments, checking and minor repairs and excludes daily servicing requirements such as lubrication but would include the time taken to change points.

A practical way of determining field efficiency is to determine the theoretical time required to cover an area and compare this with the actual time taken.

$$\% \text{ Field efficiency} = \frac{\text{theoretical time} \times 100}{\text{operating time}}$$

Typical field efficiency values for a range of different operations are listed in Table 1. The higher figures represent operations in larger fields where the number of turns is minimised.

Table 1: Field Efficiency.

Operation	Field Efficiency
Tillage - primary and Secondary working	70-85
Planting	65–85
Harvesting	60–80
Spraying	50–70

Determining the size of machine required

To determine the size of machine required, it is necessary to estimate the time available for completing a particular task.

The starting point in any matching exercise is to determine the most critical field operation. This will vary from region to region and often between farms within any one region. It is often determined by the time available to get over the area between rainfall

ISSN 0155 - 3054
Produced by: AFFS Farming systems
Created: May 1999
File No: FS99305
No of pages (4)

events. Local knowledge or a check of local rainfall records will usually help in this regard.

By knowing the time available and the operating speed, the required width can be calculated. In this calculation allowance has to be made for field efficiency. The formula then is:

$$\textbf{Width} = \frac{\textbf{area (ha) x 10 (constant)}}{\textbf{time (hr) x speed (km/hr) x field efficiency}}$$

Consider an example:

Establish the width of chisel plough that will allow the completion of 400 hectares in 8 days working 10 hours per day at 8 kilometres per hour, assuming a field efficiency of 80% (from Table 1).

$$\textbf{Width} = \frac{400 \times 10 \times 100}{(8 \times 10) \times 8 \times 80}$$

$$= \textbf{7.8 metres}$$

With this simplistic approach, the effects of any input (hours/day, speed or field efficiency) can be evaluated. Care should be taken not to over estimate either the time available to complete the task or field efficiency.

Tractor capacities

In a similar manner to selecting a reasonable field efficiency for a tillage operation it is also necessary to look at the efficiency of the tractor in converting engine power to drawbar power.

Little can be done to decrease power losses from the engine to the axle. Better maintenance and servicing will improve the efficiency of converting fuel energy into axle power but little else can be done to decrease energy losses.

However, when considering losses from the axle to the drawbar, energy is lost in order to create traction. These losses depend on the tractor type and weight, soil conditions, as well as the load being pulled.

It is important to remember that drawbar power is the product of pull and speed; where an infinite number of pull / speed combinations could be used to give the same power. Wheel tractors are designed to operate at higher speeds (greater than 8.0 km/h) and lower drawbar loads. If low forward speeds (under 5.5 km/h) and large pulls are to be consistently used, track layers should be considered.

Table 2 Typical Tractor Efficiencies.

Tractor Type	Rated Crank-shaft Power %	P.T.O. Power %	Drawbar Power (Maximum) %	Drawbar Power (Normal) %
2WD	100	85	50	40–45
FWA	100	85	55	45–50
4WD	100	85	60	50–55
Track	100		75	65–70

Note: PTO and Drawbar Power are given as a percentage of Rated Crankshaft Power

Estimating power requirements

Estimation of draft

In order to determine the draft requirement of an implement it is necessary to use a pull meter.

Estimation of likely draft requirements can be taken from the table provided. However, these values will vary according to soil type, soil moisture, depth of working, ground speed and manufacturer.

Table 3 Estimating Draft Requirements

Implement	Draft per Unit Width (kN/m)
Chisel plough	4.5–5.5
Blade plough	4.0–4.5
Disc plough	5.0–6.0
Scarifier	4.0–4.5
Cultivator	3.0–3.5
Planter	2.5–3.5

A figure for total draft can be calculated by simply multiplying implement width by draft per unit width. Considering the example using the chisel plough, then:

***Total draft = width** (m) **x draft / metre** (kN/m)*

= 7.8 x 5

= 39 kN (approx. 3900 kgf)

If a scarifier was used to replace the chisel plough, the draft per unit width would decrease to 4.5 kN/m and the resultant total draft would be 35 kN (3500 kgf). Remember this is draft or pull, not drawbar power.

Estimation of drawbar power

Drawbar power can be related to draft and speed, by using the formula below. Any one drawbar power level may be attained by a combination of pull and speed. That is, a large pull at a low speed could produce the same drawbar power as a small pull at high speed.

$$\text{Drawbar power} = \frac{\text{pull (kN)} \times \text{speed* (km/hr)}}{3.6 \text{ (constant)}}$$

Using the same chisel plough as in the previous example, the power requirements become:

$$\text{Drawbar power} = \frac{39 \times 8}{3.6}$$

$$= 87 \text{ kW (116hp).}$$

*Speed has been determined by the initial assumption when working out the required implement width.

Note:

Kilowatts (kW) x 1.34 = Horsepower (hp)

Horsepower (hp) x 0.746 = Kilowatts (kW)

At this point, it would pay to work through all of the tillage operations and determine the requirements for each, after closely considering the time available and field efficiency. The largest power requirement would be then used in determining engine power.

Estimating engine power

Once drawbar power has been calculated, a decision needs to be made about what type of tractor is to be used.

The selection decision between wheels or tracks is far too complex a topic to be covered in this chapter. Suffice to say that if set-up and matched correctly, the operating costs should be similar for either tractive type. The decision between two wheel drive and four wheel drive is much simpler as it is determined by the minimum available size of a 4WD and the maximum size of a 2WD (that is approximately 150 kW or 200 hp).

From Table 2, it is now possible to determine the size of tractor required. In using the comparative chart it would be unwise to determine engine size using the maximum power figure as conditions vary both from season to season and even within any one season. Having a little extra capacity is also a safeguard against overloading. A more realistic figure is the normal operation level.

Table 4: Tractor Crankshaft Power (Chisel plough example)

Tractor	Drawbar HP Efficiency	Crankshaft Power (kW)
2WD	$\frac{87 \times 100}{40}$	=217 kW (290 hp)
FWA	$\frac{87 \times 100}{45}$	=193 kW (259 hp)
4WD	$\frac{87 \times 100}{50}$	=174 kW (232 hp)
Tracklayer	$\frac{87 \times 100}{65}$	=134 kW (178 hp)

Conclusion

If a step by step approach is used when matching power units and implements, it is possible to eliminate the majority of guess work that is normally employed when a machinery purchase decision has to be made.

This approach is simplistic but does allow changes to any of the inputs. Care must be taken not to over estimate either the time available to complete the task or field efficiency. ■